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Communication with the Broader Science Community

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52.1 Introduction

The field of High Energy Physics (HEP) has made fantastic advances over the past two decades. The discoveries of the top quark in 1995, the tau neutrino in 2000, and a Higgs boson in 2012 are triumphs for the Standard Model picture of particle physics. Many other important developments such as the discovery of neutrino oscillations, discrepancies in some precision measurements, observation of a cosmic matter-antimatter asymmetry, the existence of dark matter and the accelerating expansion of the universe, all point to new physics beyond the Standard Model. The measured mass of the Higgs boson, while consistent with a SM Higgs, is also tantalizingly consistent with what could be expected from new physics such as supersymmetry. While much knowledge has been gained, there remain many intriguing questions to be addressed and a rich landscape of physics to be explored.

As the field has marched on to probe deeper into the nature of fundamental particles and forces, the HEP facilities and experiments have become larger, more complex and ever more expensive. The field of HEP has become international and global. The United States, which dominated the field for many decades with many world-class high-energy particle accelerators in quick succession, is now facing major challenges with regard to maintaining such world leadership. The cancellation of the Superconducting Supercollider (SSC) project in the US in 1993, the Large Hadron Collider at CERN superseding the Fermilab Tevatron as the Energy Frontier machine for HEP in the world, and the lack of a grand vision for US-based HEP facilities beyond the Tevatron, have weakened the U.S. position as the leader in the field, even while the global particle physics effort is growing stronger.

For HEP to remain a major component of the physical science research portfolio in the US, we need support from the public, policy makers and from the broader science community. The goal of the subgroup on Science Community outreach was to review previous outreach activities our field has for scientists in other fields, and develop strategies for improving communication and outreach in the future.

Our broad goals for the subgroup through the Snowmass meeting were to explore ideas on how to build rapport with scientists from other subfields, encouraging them to stand with us in areas of common cause and support a healthy HEP program in the US. In order to be able to sell our science to the broader science community, it is also critical that the HEP physicists themselves have broader appreciation and respect for all areas of HEP and support the HEP-wide plan to move the field forward. We therefore made efforts on "HEP inreach" among the three established frontiers of HEP (Energy, Intensity and Cosmic frontiers) as well as "HEP Outreach to scientists from other fields".

This report details our efforts and activities as a part of the Snowmass Community Study during the past nine months, and lays out strategies for strengthening our communities outreach efforts in the future.

52.2 Past and current outreach activities

We have surveyed past and current outreach activities of the HEP community targeted (at least partially) at colleagues in the broader science community. Below is a brief summary of the most significant efforts.

1. **Colloquia and campus-wide lectures at university departments and labs:**

   This is the bread-and-butter methodology for keeping the broader science community informed and interested in HEP. It has the advantage of being fully reciprocal, provided that HEP scientists make a point of attending colloquia and campus-wide lectures on non-HEP topics at their home institutions. Another advantage is that such talks have significant overlap with faculty hiring processes, and serve to keep the vibrancy and relevance of HEP fresh in the minds of department chairs and university/lab administration. Since colloquia and lecture series are regular locally-organized events, there is a low threshold required to achieve ¿200 HEP talks annually at U.S. institutions.

   It is clear that some HEP groups put stronger efforts than others towards achieving the best possible quality, impact, and frequency of HEP colloquia and lectures. The stronger efforts take advantage of news-making events (recent examples include the Higgs boson discovery, DES first light, dark matter detection anomalies, LHC turn-on), recruit dynamic speakers (including younger rising stars and speakers from under-represented groups), and work hard to publicize the lectures and ensure broad attendance.

2. **Plenary sessions organized at APS and AAAS meetings:**

   HEP research scientists constitute only a few percent of the membership of the American Physical Society. The annual APS April meeting is a good opportunity to reach out to the other participating units, including the Divisions of Astrophysics, Nuclear Physics, Computational Physics, and the Physics of Beams, Forums such as Education, Graduate Student Affairs, Physics and Society, and International Physics, and Topical Groups such as Gravitation, and Hadronic Physics. Because of the large overlap between these disciplines and HEP, there is even the opportunity to organize joint sessions at the April meetings shared between the DPF and other units. This of course guarantees the attendance of non-HEP scientists at HEP talks. Some DPF vice-chairs (traditionally the chief organizers of HEP sessions at the April meetings) have taken very considerable advantage of this opportunity, while others have not.

   The APS March meetings are nearly ten times the size of the April meetings, due partly to the participation of the Division of Condensed Matter Physics, and the fact that for U.S. condensed matter physicists this is their premier annual meeting. The question has been broached in the past of whether it might be a good idea to merge the March and April APS meetings, partly so that DPF and other units could have direct contact with the full range of APS membership. However there are some considerable drawbacks to such a merger, and it has never been seriously contemplated by the APS in the past.

   Thus any HEP presence at the APS March meetings has required organizing special sessions, done on a year-by-year basis. In spite of this higher threshold, a number of successful high-profile sessions with HEP content have appeared in the past decade at March meetings. These have included both interdisciplinary panel discussions and topical lectures.

   There is, however, a recent development in this regard: the APS has now plans to hold combined March and April meetings once every 10 years or so. The next combined meeting is likely to be 2019. We are proposing that APS consider merged meetings at shorter intervals, perhaps every five years, assuming that a workable model is achieved. We have also suggested that the 2018 meeting in New Orleans could be restructured into a combined meeting, since the added April meeting influx is only

Figure 52-1. *Panel discussion on "American Science and America's Future", hosted by the Forum on Physics and Society, 2012 APS April Meeting. Frank Wilczek, Neal Lane, Tim Hallman, Jim Siegrist, Pushpa Bhat*

a 10% increase to the normal March meeting attendance and could probably be accommodated. It might be useful to add two extra days when combined meetings are held.

3. **Publication of HEP results in journals such as Science and Nature:**

   HEP scientists and experimental collaborations generally submit their high-profile research papers to the Physical Review and its international counterparts, rather than to Science or Nature as is more common in other scientific disciplines, including other branches of physics. This has the considerable downside of minimizing the presence of HEP in what are unquestionably the two most-read premier scientific journals. Some HEP scientists who have considered submitting research papers to these journals have been discouraged by the strict embargo policies, which obviously cut against the grain of nearly universal web pre-publication of HEP results. A handful of HEP research papers have appeared in these journals (results from the DZero and CMS experiments are examples), but most coverage of HEP is in the form of short reviews written by HEP scientists, and news articles written by staff writers of the journals. Obviously there is considerable room for improvement here.

4. **Articles written by HEP scientists in Scientific American, Physics Today, and similar magazines:**

   Articles in Physics Today reach a broad audience of physicists and physics students, at a technical level similar to that of a departmental colloquium. Articles in Scientific American reach an even broader audience of students, scientists and non-scientists, at a non-technical level. Such articles also influence the content and slant of articles in popular science journals written by professional science writers.

5. **Science blogs, social media, and other online activity:**

   Online blogs written by HEP scientists or scientists in related disciplines have become both popular and influential in recent years. Notable examples include Cosmic Variance (which has featured several HEP scientists and, until very recently, Sean Carroll), Matt Strassler's Of Particular Significance, Peter Woit's Not Even Wrong, the multiple-author Quantum Diaries, which led to spinoffs such as Tommaso Dorigo's blog A Quantum Diaries Survivor, Adam Falkowski's Resonaances, and Michael Schmitt's Collider Blog. These are all serious efforts to explain the very latest developments in HEP and related areas, including sometimes pointed criticism of perceived over-hyping or other sins by HEP colleagues in other venues, including conference talks and press quotes.

   These blogs are read by a broad range of both HEP and non-HEP people including students and large fraction of science journalists. Putting out a good serious blog requires a major commitment of time and energy, with a rather tenuous connection to career advancement. The fact that these blogs are sometimes critical of other HEP scientists (usually in a substantive, rather than personal way) probably makes them more credible and attractive to non-HEP readers (in short, this is a good thing).

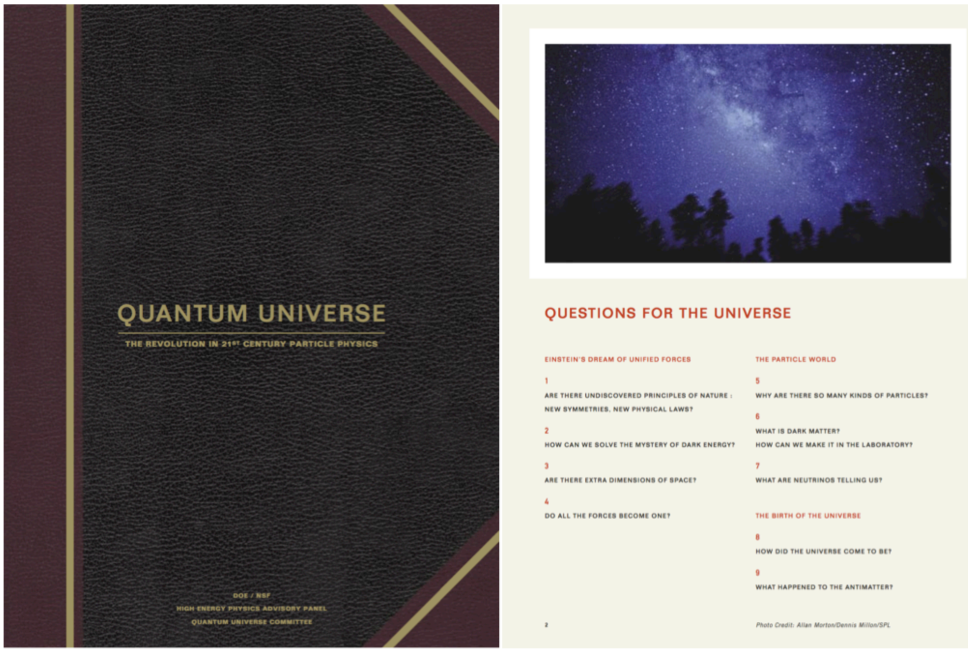


Figure 52-2. *The DOE/NSF HEPAP report Quantum Universe [1].*

There is also a large and growing amount of activity by HEP scientists on Facebook, Twitter, and other social media. These posts reach a smaller number of students and non-HEP people, but have a more intimate inside feel that probably increases their impact.

6. **Popular science books with HEP authors:**

   Popular science books written by HEP scientists or scientists in related disciplines reach a broad audience that includes students and non-HEP scientists. Best-sellers such as Brian Greene's *The Elegant Universe* or Lisa Randall's *Warped Passages* serve not only to interest a broader audience in HEP topics, but also to validate the idea that HEP remains a premier discipline with an exciting future. It is not lost on physicists in other subfields that a significant number of their students were attracted to physics in the first place by one of these books or by an inspirational encounter with one of their authors.

7. **Brochures commissioned by Labs and Agencies:**

   The 2004 DOE/NSF HEPAP report *Quantum Universe* [1], together with the 2003 NRC report *Connecting Quarks with the Cosmos* [2], marked a revolution in the format and impact of reports commissioned by U.S. funding agencies in the physical sciences. These reports were widely admired by non-HEP scientists, and have since been widely and successfully imitated. One valuable collateral effect of Quantum Universe and its follow-ups is that they gave a distinct impression to non-HEP physicists that HEP people "have their act together", and that HEP is addressing an impressive list of compelling scientific questions. The importance of these "big questions" was subsequently mirrored in broader reporting on science, again helping to cement the idea that HEP is a vital field with a bright future.

All of the above mentioned activities have been and continue to be useful in informing scientists in other fields about the latest work being done and results from HEP, and such activities should be encouraged, continued, and expanded where appropriate. One aspect where we clearly need improvement is finding more opportunities for direct, reciprocal engagement with scientists in other fields. We need to think outside the box.

52.3 Pre-Snowmass Activities

Following discussions at the Planning meeting held at Fermilab, October 10-12, 2012, we had several informal and formal discussions within the HEP community and with non-HEP scientists at meetings such as the AAAS meeting in Boston, February 2013, and the 2013 APS spring meetings in Baltimore and Denver. We had discussion sessions at the April APS meeting with invited speakers and a meeting at Fermilab regarding HEP inreach and outreach.

The Snowmass CE&O group performed a survey among the members of the APS Division of Particles and Fields (DPF). We had included two survey questions in the CE&O survey regarding HEP in the context of the broader science community. The survey questions sought to inquire how HEP physicists thought their field was being perceived by their colleagues in other fields, and what in their opinion is the best way to broaden support for HEP. The survey questions and the responses are shown in Fig. 52-3.

It is seen from the responses that a large majority of HEP physicists thought that HEP is regarded well or highly regarded by colleagues in other fields. A majority also felt that it is important for us to foster interconnections with other disciplines and engage in stronger outreach to scientists in other fields.

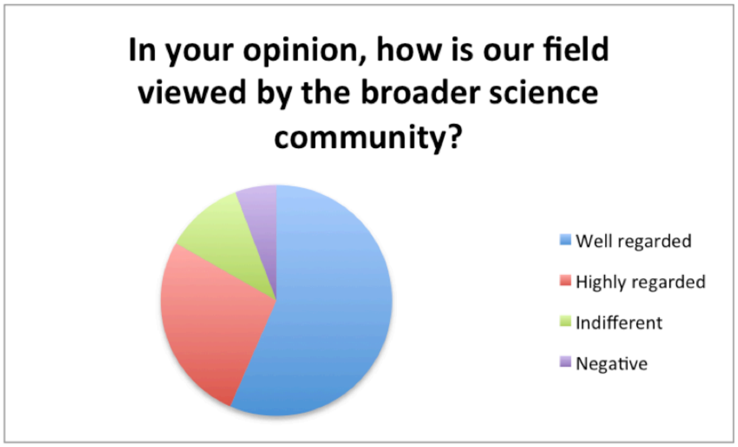
52.4 Fostering Connections with other Sciences

Particle physics research has impacted other areas of science in a significant way. Examples include accelerator and detector technologies with applications to photon science, neutron scattering, muon spin relaxation, medicine, and a variety of industries, and handling of big data and large scale computing. Besides these technology impacts, scientific connections to other fields of science such as nuclear physics, astrophysics, materials and space science have grown over time and can be further strengthened in the future. Opportunities for improving connections in overlapping areas and for leading interdisciplinary efforts have to be embraced. To this end, the DOE/NSF High Energy Physics Advisory Panel (HEPAP) has recently established a working group on "Science Connections", co-chaired by Shamit Kachru and Curt Callan, with a charge to highlight the scientific areas where HEP advances, informs, and benefits from other DOE Office of Science programs. Such a report has not been attempted since the 1998 National Academy EPP Decadal Survey chaired by Bruce Winstein.

As part of the Snowmass process, we invited some distinguished scientists from other sub-fields of physics and organized a panel discussion during the meeting in Minnesota. This is summarized in the next section.

52.5 HEP Inreach/Outreach Discussions at the meeting in Minneapolis

We organized three discussion sessions at the CSS2013 meeting in Minneapolis.



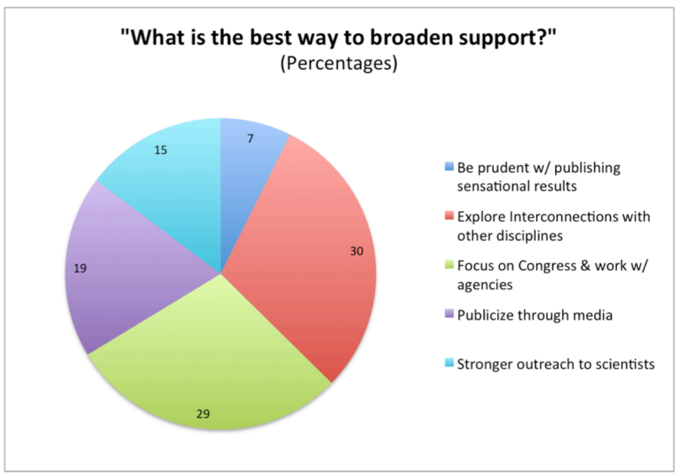


Figure 52-3. *Responses to our survey of members of the APS Division of Particles and Fields.*

1. **HEP Outreach Panel Discussion: Fostering Connections and Common Cause with Scientists in Other Fields**

   This panel had a mix of high-energy physicists and condensed matter, astronomy, astrophysics and theoretical physics colleagues.

   Our panelists were:

   - Laura Greene (Condensed Matter Physics, U. Illinois)
   - Terry Jones (Astronomy, U. Minnesota)
   - Hitoshi Murayama (Theory, UC Berkeley/Kavli IPMU)
   - Robert Rosner (Astro- and Computational Physics, U. Chicago)
   - Randy Ruchti (HEP, Notre Dame)
   - Harry Weerts (HEP, Argonne)
   - Moderator: Pushpa Bhat

The discussions at this session provided many ideas for future interactions for HEP with scientists in other fields. The main ideas were:

- First and foremost, there has to be mutual respect for the importance and interest of science and scientists in different fields. HEP physicists have not always been the best exemplars in this regard.
- There are many opportunities for scientific interconnections and interdisciplinary collaborations. These will be fostered naturally by increasing the opportunities for informal contacts.
- HEP is already appreciated as a technology incubator for other fields.
- HEP has a lot to give and take, provided we expend the time and effort to break down cultural barriers that separate us from other scientists.
- All fields of science in the US are facing serious long-term funding problems.
- There is general recognition among US scientists in different fields that supporting each other will achieve better results for all.

Our panelists made a number of specific points worth reviewing.

Robert Rosner: The non-HEP community does not understand where the field of HEP is going next. The future of the energy frontier post-Higgs looks murky, while the intensity frontier is not well explained a price-tag of $1B for LBNE does not seem well motivated in contrast to, for example, the variety of science that can be done for $1B at a light source. The cosmic frontier is still a new thing, treated somewhat as a step-child within HEP, and the overlaps of fields are still being understood. Despite the Venn diagram used in HEP for describing the three frontiers, they are certainly not co-equal.

HEP also needs to develop better strategy and tactics for explaining the relevance and importance of HEP. The story is poorly developed and incoherent. There are no good answers given to obvious questions such as what is lost if we waited for better economic times to build the next big machine? As long as the relevance of HEP to society is not sharply articulated, the possible loss of US leadership internationally will not be seen as catastrophic. The broader physics community needs to hear and understand where HEP is going and why to support HEP publicly. There is a great case to be made for HEP, and a great story to tell. The HEP community is underselling it. Saying that HEP is “fundamental science” doesn’t make it special and offends scientists in other fields; there are fundamental aspects in other sciences too.

HEP is recognized as a technology incubator for other fields of science, although not so much directly for industry. There is a good case to be made that HEP is to condensed matter physics as condensed matter physics is to industry. This aspect needs to be the selling point.

Laura Greene: There is a perception that high energy physicists are arrogant and think that their science is the most fundamental. In fact, all physicists are considered arrogant, not just those in HEP. From outside, it looks to us like the HEP community is united, and that is how HEP is getting lots of money for their big machines. Perception is more of a problem between fields than reality; there has always been “us vs. them”. Letting bad perceptions fester will only make it harder for everybody. All areas of physics are under increasing funding pressure, not just HEP.

No one field of science has a legitimate claim to being “more fundamental”. Strongly correlated electron systems make understanding the Higgs look like a walk in the park. There is collaborative work going on between condensed matter (CM) and string theorists around applications of AdS/CFT duality: this is the first time in my career that I have seen a CM/HEP scientific overlap that looks like it is going somewhere, but we will have to see how this turns out.

Randy Ruchti: There are many areas of commonality between HEP and other sub-fields of physics. Last year NSF physics allied funding increased from $7M to $20M while elementary particle physics (EPP) funding itself went down by $10M. The gains in allied funding come from many other programs: BIO, CISE, ENG, and SBE. NSF also has interdisciplinary initiatives; a recent example is the initiative on Data Access and Open Science (DASPOS): supported by NSF Physics Division and three other divisions. If we are pro-active and try to identify common ground and methodology for solving problems in different sub-fields, we can increase our resources. The lesson is: be pro-active!

Harry Weerts: There are many examples of interdisciplinary collaborations at Argonne National Lab. In other sciences it is usually not normal to build big new instruments from scratch; instead they generally use and re-use existing instrumentation. HEP requires new, unique, large detectors with complex instrumentation. We need smaller feature size and more sensitive detectors, so our challenge is not just making things bigger. In Argonne HEP division, we have made collaborations based on our expertise to actually build things. At the same time Argonne HEP looks to take advantage of expertise elsewhere in the lab; for example at Argonne we are leaders in materials by design, which sounds like it should have great potential for applications in HEP. When an expert in atomic layer deposition asks, "is there a magic material that we can make for you? this gets our attention. Can expertise in other sciences help us?

Some examples of interdisciplinary collaborations at Argonne are:

- Superconducting radio-frequency cavity (SRF) technology R&D, where the goal is to improve accelerating gradients using layered structures, combining expertise in superconductivity and atomic layer deposition. A joint position has been created at ANL between HEP and Materials Science for layered superconductors with RF fields.
- Bolometer sensing devices for the SPTpol next generation cosmic microwave background polarization measurements with the South Pole Telescope.
- Large-scale picosecond timing photo-detectors, with applications to HEP particle detectors and much more broadly to industry.
- The new computational cosmology group established at ANL HEP, with joint positions in high-performance computing, and connections to the MIRA Blue Gene/Q supercomputer.

DOE HEP is supportive of our interdisciplinary efforts, while other offices in DOE SC have sometimes been more cautious. We have learned by experience that we must be able to communicate meaningfully with scientists in other fields: don't speak in acronyms. Patience and persistence has been essential to our success. Initial seed funding from LDRD is also key.

Terry Jones: My knee-jerk perception about HEP is that it is roughly split between two activities:

- Giant accelerators that produce two numbers after a few years of running and then become obsolete and are abandoned. Note that this is not what happens in astronomy, where our big machines – telescopes – do not become obsolete; we upgrade and keep using them.
- Everything else you do, which now includes a big overlap with astronomy.

It has not been my experience that you are more arrogant, and act like your science is more fundamental. I think that the different approach of HEP physicists in joint efforts with astronomers has been beneficial. Astronomy is like paleontology: we can't do experiments; we look and receive. But now from HEP we are influenced to build specific instruments to look for specific things and answer specific questions, such as can we detect the B-mode polarization in the cosmic microwave background. This is a healthy overlap.

Hitoshi Murayama: HEP people are sometimes perceived as arrogant, narrow, selfish, and greedy, so we have some work to do there. More than 90% of the public can't tell physics, math, and astronomy apart, so we might as well work together with other scientists, since in this sense we are all in the same boat anyway. Combining HEP and astronomy together is great for outreach, and does not offend astronomers since they see it as also promoting astronomy, not co-opting it. Dark energy with telescopes is a win-win if we promote new instruments that are used for both dark energy and astronomy. We need to work harder to understand differences in scientific culture. Basically we don't know each others language; just listen to our own jargon: What is CPV? What is θ_{13}? We can do more to develop mutual respect and give credit; for example, the idea of the Higgs mechanism came from superconductor theory in condensed matter physics. Now in HEP we use AdS/CFT ideas to try to go the other way and stimulate new insights into condensed matter physics.

2. **HEP Inreach Panel Discussion: Communication across the Three Frontiers of HEP**

   This panel had a mix of high-energy theorists and experimentalists. The goal for this session was not only to discuss challenges and strategies for communication across frontiers within HEP, but to try to facilitate a discussion that would bring the three frontier proponents to see the need to weave a more unified story for HEP.

   Our panelists were:

   - Joel Butler (Energy Frontier, Fermilab)
   - JoAnne Hewett (Theory, SLAC)
   - Steve Ritz (Cosmic Frontier, UC Santa Cruz)
   - Maria Spiropulu (Energy Frontier, Caltech)
   - Moderator: Joe Lykken

   One of the concerns voiced within the community has been regarding the Venn diagram used for the visual representation of the three frontiers while being a tool for the funding agencies to promote and support a more modern view of the field, the resulting stove-piping, those concerned said, threatens to effectively turn the field into three disjoint communities fighting for the same budget. The discussion on this topic elicited comments on the pros and cons of the frontier representation. In the end, there was a consensus that we need analogies such as these, maybe more of them rather than eliminating what we now have, and we need to be careful to use them in a positive way rather than to impose limits.

   It was the general consensus that the future success of our physics will require an inter-weaving program that is agile and maximizes the input from all the frontiers, even if in a temporal and spatially asynchronous way.

3. **Discussion on the HEPAP P5 Prioritization Process**

   The third session we organized was a community discussion on the HEPAP P5 prioritization process that is just getting underway now, charged with producing a roadmap for US HEP in the next decade or two, with a report due in May 2014. The HEP community has been frequently told, from various quarters, that it has to buy in to the prioritization process and support the resulting plan. This community discussion provided an initial unique opportunity for the HEP community to express its views and provide input to the agency leaders and the HEPAP chair about concerns with the process. This discussion itself was a good first step towards a new roadmap that the HEP community will take ownership of and support.

52.6 Strategies and Implementation

As a result of many meetings, small and large discussion sessions, solicited advice from experts within and outside HEP, and deliberations over many months, we have developed the following strategies and implementation plans to help the HEP community achieve the goals enunciated above.

Overall Goals for particle physics communication, education and outreach

The CE&O group as a whole identified the following as the three overarching goals of U.S. particle physics CE&O activities. Activities aimed at the policy maker and opinion leader audiences generally support the first two goals.

1. To ensure that the U.S. particle physics community has the resources necessary to conduct research and maintain a world leadership role.
2. To ensure that the U.S. public appreciates the value and excitement of particle physics.
3. To ensure that a talented and diverse group of students enter particle physics and other STEM careers, including science teaching.

Strategies targeted to the Science Community

1. Foster more dialog and understanding between subfields of science.
2. Identify areas of common cause and unite in support of them.
3. Develop consensus in our field that we need to prioritize, buy into the mechanism of prioritization, and then support the resulting plan.

Implementation of the Strategies targeted to the Science Community

1. Work with APS to create and foster new opportunities for dialog between leaders of physics subfields.
2. Hold combined open sessions at March/April APS meetings to disseminate the better understanding and the identified common causes.
3. Following our initial start, continue the community discussion about the prioritization process for HEP so that the members of the community will support the resulting plan irrespective of how their favorite activities fared.
4. With the help of APS, create and foster new opportunities for interaction with fields beyond physics.

52.7 Conclusion

High-energy physicists have a great story to tell about recent discoveries, the compelling questions that inspire our field, and how the challenges of addressing those questions drive technology innovation. All aspects of this story have overlaps with other areas of science: the Higgs boson discovery has its roots in the theory of superconductivity, big questions of particle physics tie into big questions of cosmology, and technologies for high-powered accelerators and ultra-sensitive large detectors have uses far beyond HEP. Our basic research is undertaken in a much larger context of basic research in the physical sciences, which in turn feeds progress in chemical and biological sciences and acts as a powerful innovation engine for the US economy.

The HEP community already engages broadly in activities at many levels that reach out to and impact on scientists in other fields. These range from popular accounts and lectures on HEP science results, to interdisciplinary scientific and technical collaborations on major projects. We can point to many successful examples of such outreach, as well as many strong ongoing efforts.

But given the importance of standing together and finding common cause with scientists in other fields, HEP physicists need to work harder on making and nurturing these kind of connections. Our future efforts must begin from a posture of genuine interest and respect, and indeed, we need to do a better job in this respect across the frontier boundaries of HEP itself.

During our first panel discussion, condensed matter physicist Laura Greene was asked how HEP physicists could break down the barriers between HEP and other fields. “Start by going to lunch”, she replied. Science is, in the end, a human activity, and scientific connections are forged from human connections.

References

[1] *Quantum Universe*, http://www.interactions.org/quantumuniverse/.

[2] *Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century*, National Academy Press, 2003, http://www.nap.edu/catalog.php?record_id=10079